Writing a lab report

James R. Graham
8/24/2013

An experiment is only finished when you have written up your findings, so in some sense writing your lab report is the most important step. Your lab report must communicate your findings clearly and convincingly—the purpose of this note is to help you accomplish these goals.

1 Contents

A lab report is a written description of your activities and findings that comprises:

- The title of the experiment.
- The date, your name, email address, and other contact information. Include the names of your lab group partners in the introduction with a description of any division of labor that occurred.
- An abstract that summarizes the objectives, methods, and principal conclusions.
- An introduction that outlines the problem you are exploring and the methods used.
- A brief description of the equipment that you used and information relevant to the experiment (time, date, personnel involved). There is no need to quote extensively from lab handouts.
- A description of how the data were acquired.
- A log or summary of observations (e.g., a table). Description of any anomalies or systematic errors that might be present in the data.
- A description of data reduction methods and algorithms. Explain what statistical methods were used to analyze or combine the data into your final result. Describe how you estimated the uncertainty in data.
- Comparison of the results achieved with theoretical expectations and an exploration of any deviations.
- Summary of conclusions.

AY 120 lab reports should not exceed ten pages (including tables and figures.) Use single spaced lines and 12-point Times font and 1-inch margins. Please print your reports using the duplex option so that both sides of the paper are used.

2 Writing the report

A blank page can be intimidating. Always start with an outline—you can use the one above in §1. When you have sketched an outline, you have a map of where you are going and a way to estimate how much time and effort will be needed to finish your task. The outline will also help you figure out if you have forgotten any important steps. Here are some ideas to help you get started and to follow through to a satisfying conclusion.

- Set out your thoughts in an outline that organizes and directs the logical flow from introduction to conclusions.
- Some people write outlines and then fill in the details as they proceed: others may or may not follow the outline, or even consult it as they write; however, thinking through the structure and logic of your report will help focus your writing and lead to text that is easier to read. The first outline does not have to be complete—you can refine and expand it as you proceed.

- When you have an outline, you do not have to work sequentially from start to finish. You can start the outline before you complete the experiment. Even if you do not know what your conclusions are you can still write a bullet that says "Conclusions."
- Think before you write! Clear thinking precedes clear writing. The clearer the ideas are in your head, the clearer they will be on the page. Thinking through your report should leave you with a solid understanding of what you want to say.
- Be explicit. A lab report is not a drama or a mystery where the story is resolved at the end. Never assume that the reader knows what you mean or where you are going. State your objectives and methods early on.
- State the principal results, both the intermediate ones and the final ones. Results are not just a table of numbers—describe the results in the text. Although a table may contain the actual answer, the reader will need help interpreting these results—hence the need for a description. We do not just want the answer: we want to see how you got there! You are writing for a critical (but not antagonistic) reader. You need to convince the reader that at each step you have likely done the right thing. Finally, never quote a number with out stating the uncertainty and the units.
- Get your lab partners to read your report. Do not be proud. Remember, you are not just writing for yourself.

3 Style

A lab report is a narrative recording your activities. In a lot of writing style is an important consideration. Clarity trumps style in scientific writing; the clearer your report, the easier it will be for the reader to understand and follow your logic and writing. If you cannot explain what you have done clearly, it probably means that you do not understand it either—and you certainly will not convince anyone else that you know what you are describing. Some tips for clear writing include:

- Work from a plan or outline (see §2). You may find it helpful to flush out each item in your outline into several concrete subtopics. Each topic in the outline will likely deserve a section heading in your report. Use subsections to refine your direction and purpose.
- Flush out your thoughts into paragraphs. Use a topic sentence to focus each paragraph so that reader knows what is coming next.
- Keep it simple. Write to express, not to impress! This means writing in short, simple sentences using common vocabulary and syntax. Use simple verbs and place them next to their subjects. Do not get tied down in complex clauses or language that may be ambiguous.
- Brevity enhances clarity. Try to convey the maximum information in the minimum number of words. Avoid wordiness—eliminate unnecessary determiners and modifiers; change phrases into single words; change unnecessary that, who, and which clauses into phrases; use active rather than passive verbs; replace circumlocutions with direct expressions. Watch out for weasel words and phrases, e.g., "it is known that… ," "experience shows … ." You can find examples at:

  http://owl.english.purdue.edu/owl/resource/572/01/

  These techniques will give you more room to convey important information.
- Read what your write and seek criticism! Talk about your ideas with others at different stages of writing your report. Get your roommate, lab partner, TA, professor, friend, sibling, or parent, to read your work. Remember, you should be your own severest critic. Finish your lab report a day early (!) and then reread at least eight hours later.

- Conventional spelling and grammar counts. Use the spell checker.
- Avoid colloquial and informal language. Don't use contractions! Use acronyms sparingly, and define them on first use.
- Use bullets sparingly! Save them for making important points.

The most enjoyable way to learn about clear writing is to read those who practice it well. Here are some examples: Carl Sagan: "Cosmos"; "Demon Haunted World"; "Pale Blue Dot". Sagan remains one of the best and most influential science writers. John McPhee: "Annals of the Former World," "The Curve of Binding Energy." McPhee writes on many topics, but his essays and books on geology are superb. Other science writers to watch out for are Elizabeth Kolbert, Timothy Ferris, Richard Dawkins ("The Selfish Gene"; "The Blind Watchmaker"), Peter Galison ("Einstein's Clocks, Poincare's Maps"), Stephen Jay Gould ("Wonderful Life").

3.1 Equations, figures, & tables

Equations, figures, and tables are key elements of your report. In the main body of the report, show all relevant equations that you used. Equations should be labeled with equation numbers so that you can refer to them in the text. If you quote an equation without derivation, cite the reference. Use equations as you present the explanation of what you did. When you include an equation, the text preceding and following it will explain in words what the equation means. Equations are delineated by punctuation because they are part of sentences. For example, put a period after an equation if it ends a sentence. The text preceding or following an equation should always define any new symbolic quantities that are used for the first time.

Put tables and graphs in the text close to where they are referenced instead of attaching them at the end. This way it is easier to link the discussion to the data. Equations, figures, and tables must have numbers so that they can be referenced in the text. We strongly encourage you to used a document preparation system, e.g., LaTeX, which allows automatic cross referencing of document elements and update figure and equation numbers as new elements are added to the document.

Figures and tables must be labeled. Plots must have axis labels specifying quantity and units, and each figure and table should have a text caption that describes what is shown. A figure or table important enough to include in the report should be discussed and referred to by figure number in the body of the report. Figures and tables that are not mentioned in the text will be ignored.

It is preferable to do all figure labeling in Python, but not required. It is better to have a graph labeled by hand than not at all. You will find it faster and more accurate if you learn how to do this on the computer. Use the `MATPLOTLIB` options `TITLE`, `XTITLE` and `YTITLE`.

4 Collaboration & cooperation

Collaboration is an essential aspect of lab work. Working together is also an effective way of learning. However, when it comes to writing your report and presenting your data, this must be an individual effort. You can and should discuss getting data and understanding it. But the act of presenting it must be your own effort. It is easy to cut and paste text and figures from one report to another: such activities will not be tolerated from either party. If you include a figure or plot generated by another student you must give credit to the source in the figure caption. Presentation of figures from other students should only be used for the purpose of comparison with you own work.